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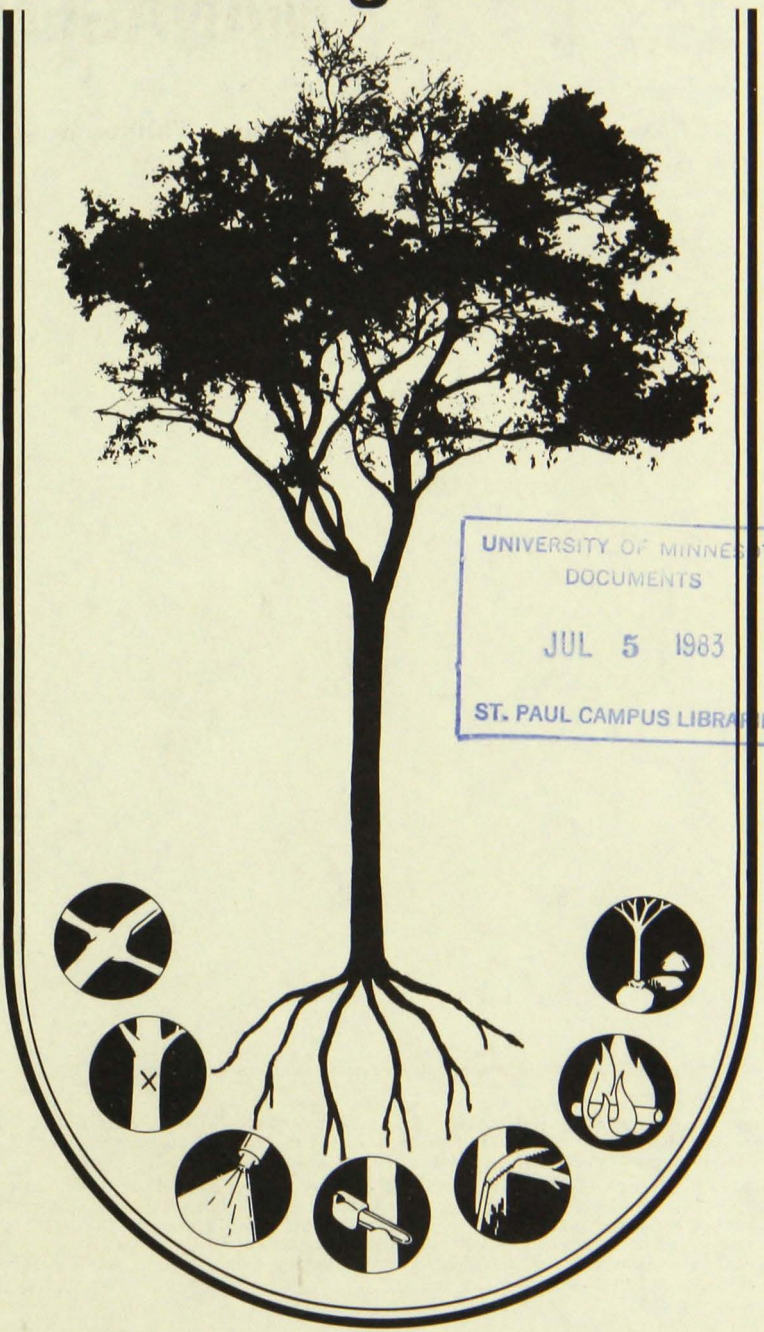
AN INTEGRATED APPROACH TO

Dutch Elm Disease Management



Agricultural Extension Service, University of Minnesota

AN INTEGRATED APPROACH TO DUTCH ELM DISEASE MANAGEMENT

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In recent years, Dutch elm disease has reached epidemic proportions in Minnesota. Unless appropriate action is taken, many communities could lose up to 95 percent of their elms by the 1990s. Although there is presently no cure for Dutch elm disease, it is still possible to save many existing elms and to slow the advance of the disease, allowing communities time to replant and to spread the cost of combating Dutch elm disease over a period of years.

More than 500 Minnesota communities have been engaged in Dutch elm disease (DED) programs. The most successful have employed an integrated approach to DED management. In Minneapolis, for example, a concerted effort to manage the disease, begun in 1977, started paying dividends within a year. The city lost 31,500 elms in 1977, 21,000 in 1978, 7,000 in 1979, and 4,200 in 1980. Sixty-five percent of the city's elms were still standing in 1980.

An integrated approach to Dutch elm disease involves using a combination of measures rather than focusing on just one aspect of control. Communities that have used just one method—for example, pruning—have failed to effectively manage the disease.

Management techniques include: detection, root graft disruption, removal, disposal, spraying insecticides, injecting fungicides, selective and clear cutting, pruning, using biological and natural factors, and replanting. Of these, the first four—detection, root graft disruption, removal, and disposal—are the most important. This bulletin explains all the various methods, shows how they are related, and points out the problems as well as the benefits of each. A list of publications containing additional information on Dutch elm disease management is also provided.

Organizing a Management Program

Strong cooperative leadership, public involvement, and technical know-how are the keystones of an effective DED management program. Communities that have combined these factors have been the most successful in stabilizing or reducing the rate of Dutch elm disease.

COOPERATION

Elected officials, community foresters, county extension agents, and interested citizens should all be involved in planning and implementing a DED management program. By using shade tree advisory boards and holding joint meetings of the various agencies involved, sound decisions can be made on the needs of the community, the resources available, priorities, and strategies for managing the disease.

On occasion, several communities may combine their resources to accomplish a particular task, such as an elm utilization project.

The county extension agent can help organize and coordinate joint-powers agreements between communities embarking on such projects.

Whether it's a single community or a joint project, cooperation among those involved will help insure the program's success.

PUBLIC INVOLVEMENT

The importance of public awareness and involvement in curbing Dutch elm disease cannot be overemphasized. The success of a DED management program depends to a large extent on public understanding, cooperation, and support.

The county extension agent can play an important part in generating public involvement. Through radio, television, newspapers, public meetings, and displays (set up at county fairs, banks, shopping centers, etc.) the county agent can inform the public about Dutch elm disease and what individuals can do to retard its spread. The agent may help organize elm watches or telephone hot lines for detecting infected elms, elm sweeps for detecting downed elm wood with intact bark, and tree tours to heighten public awareness of the value of trees (figure 1). County agents also can act as a liaison between the community and resource people at the University of Minnesota or other state agencies.

An informed public helps community foresters carry out their duties effectively. Educated citizens are also less likely to be victimized by unethical salesmen offering "cures" for Dutch elm disease.

TECHNICAL KNOW-HOW

Detection and removal of diseased elms, recommendations on appropriate management techniques, and the implementation of those techniques are basically the responsibility of the community forester or tree inspector. Professional expertise can also be provided by University agricultural extension personnel. Extension publications dealing with various aspects of Dutch elm disease management are listed at the back of this bulletin.

Primary Management Strategies

All Dutch elm disease management programs must include four essential strategies: detection, root graft disruption, removal, and disposal. Used properly, these measures can suppress the disease and prevent its spread. Other management techniques are considered supplementary to the "basic four."

Figure 1. Tree-planting demonstrations can help heighten public awareness of the value of trees.

DETECTION

Detection involves the systematic inspection of all potential DED hazards in a given area (the DED control zone). Community foresters, who are familiar with the ways the disease is spread and are trained to recognize all disease hazards, conduct these surveys throughout the year, covering the entire control zone each time. From March through October, a full survey is made every two weeks.

Foresters generally cover the DED control area on foot, using a map of the area to insure a thorough survey. They inspect all trees, using binoculars to spot DED symptoms in the crown. They inspect both standing trees and downed wood, indicating the DED hazards on the map and recording the address. Diseased trees requiring removal are measured at breast height (4.5 feet) with a "D" tape (diameter tape), the diameter is recorded, and the tree is marked with a bright spray paint.

Foresters are equipped to take samples of suspect trees. Pole pruners and hand-held pruning shears are used to remove samples

of wilted branches. A bucket truck helps to reach suspect branches higher in the tree. The samples are placed in plastic bags containing wet paper toweling to keep them moist, and the bags are tagged with information on the tree location, tree size, and amount of wilt. They may be sent for identification to the Dutch Elm Disease Laboratory, Division of Plant Industry, 90 Plato Blvd., St. Paul, MN 55107. To check for numbers and type of elm bark beetle present, the forester removes the bark from downed elm wood with a small axe or hatchet. This information is recorded, since it may indicate if insecticide application is necessary (see page 12). The forester also removes some bark from the trunk of diseased trees to check for staining due to Dutch elm disease. This information helps the forester decide if root graft barrier installation is required (see page 7).

During the winter months, detection efforts are concentrated on locating elm firewood with intact bark, undebarked elm stumps, and broken elm limbs greater than two inches in diameter. These materials are hazards because the DED fungus and its carriers, the elm bark beetles, grow and reproduce in dead and dying elm wood.

In early spring (usually mid-May), community foresters begin checking standing trees. They closely monitor suspect elms recorded the previous fall for slow or absent flowering or bud break and for internal symptoms. They also watch for any elm that is slow to leaf. Since winter kill, storm damage, or other stresses can also cause slow development, community foresters do not mark elms for removal until further DED symptoms appear.

During late May and early June, at the time of full leaf expansion, community foresters begin looking for foliar (leaf) symptoms. Initial DED foliar symptoms (drooping, yellowing, and curling) appear at this time and elms infected the previous fall may show signs of massive wilt. Those trees with greater than 50 percent wilt are designated "high risk" and are given top priority for removal. Structually weakened elms, even if not infected with Dutch elm disease, are also marked for pruning or removal, since any dying or dead elm wood, diseased or not, can serve as a breeding site for the elm bark beetle. Community foresters continue, on a biweekly basis, to inspect for slow-wilting trees and flagging symptoms until fall coloration masks the symptoms. During these inspections, records should be kept of whether beetles or root grafts caused the infection. (Trees infected by beetle carriers show initial symptoms high in the crown and the wilt progresses down the tree, whereas trees infected through root grafts show symptoms on the trunk first and the wilt progresses up the tree.) This information indicates whether the program is weak in reducing beetle numbers or in establishing root graft barriers.

In most municipalities community foresters have a pickup truck at their disposal to carry branch samples and equipment and to drive to the area to be inspected that day. Surveys can also be done by air. Although aerial surveys are fast, less expensive than ground surveys, and helpful in spotting crown symptoms, a ground backup crew is still needed for sampling suspect trees and marking diseased ones.

Community foresters can enhance their inspection programs by enlisting public support. With the cooperation of local county extension agents, they can establish elm watch groups or telephone hot lines for gathering and using information on suspect elms provided by community residents.

There are some special detection problems that community foresters should be aware of. Backyard elms are often overlooked during a survey because they are partially or completely hidden from sidewalk or street view. Broken branches can mistakenly be attributed to Dutch elm disease. Insects other than elm bark beetles can cause leaf damage that may mask or superficially resemble DED symptoms. Other diseases (e.g., native elm wilt), salt damage, dieback (common in Siberian elms), or mechanical damage to elm roots during street widening operations can all cause foliar stress. Whereas foresters must realize the importance of early detection followed by prompt removal, they should not become overzealous in marking trees or too quick to diagnose the problem as Dutch elm disease.

A Detroit study has demonstrated that three surveys during the summer, followed by prompt removal, were superior to one survey, followed by fall or winter removal, in limiting the spread of Dutch elm disease. After a three-year period the disease rate in areas inspected three times was 6 percent compared with a 12 percent rate for areas inspected once. Minnesota communities using the more frequent surveys recommended in this bulletin in conjunction with prompt removal and disposal have kept their losses to 2 to 4 percent per year.

ROOT GRAFT DISRUPTION

Tree-to-tree spread of the DED fungus may occur through root grafts connecting adjacent elms. The breaking of these connections between diseased and healthy trees is an important DED management strategy which unfortunately has been overlooked by many communities. In communities that have omitted root graft disruption, even though incorporating early detection, prompt removal, and proper disposal, root graft transmissions have accounted for more than 50 percent of new DED cases. This technique must be combined with the three other primary methods if a DED management program is to be successful.

Mature elms spaced closer than 40 feet have a high probability of being joined by their roots. If an elm shows early DED symptoms in the crown and the nearby elms appear healthy, there is a good chance to save the adjacent elms through root graft disruption. Grafted elm roots can be severed mechanically or root segments can be killed chemically.

Mechanical root graft disruption works well in parks and open spaces. Roots can be cut by digging trenches about 3 to 4 feet deep midway between infected and healthy trees. Vibratory plows or soil trenchers are used; however, their use is not feasible in many locations due to the presence of pavements, underground utilities, or rocky soil. Soil trenchers leave a hole that has to be refilled, whereas the vibratory plow cuts a barely noticeable seam in the soil (figure 2). After the diseased tree has been isolated, it is promptly removed.

Along boulevards, the usual treatment of choice is a soil fumigant, SMDC (sold commercially as Vapam), poured into a series of holes placed between the diseased tree and its healthy neighbor. The fumigant is usually applied in summer, since soil temperatures must be above 50°F. A primary line of treatment is established halfway between the diseased elm and its healthy

Figure 2. It is important to check for the presence of underground utilities before using a vibratory plow to disrupt root grafts.

neighbor. The line should extend beyond the drip line (tips of branches) of the trees. If the elms are closer than 18 feet, there is a possibility of injury to the healthy tree. In this situation, the fumigation holes should be placed closer to the diseased elm. Since the neighboring tree may have already been infected via root grafting, a secondary line of treatment should be established between the neighboring tree and adjacent normal elms.

Unlike mechanical disruption, where the tree is removed immediately, after chemical fumigation the diseased tree is not removed for at least 10 days. This allows the chemical time to penetrate the soil and destroy the root grafts. Although fumigation has the disadvantages of being slower than trenching, of possibly failing to destroy large roots (more than 1½ inches in diameter), and of killing turf in a strip 8 to 12 inches wide along the treatment line, it is often the only means possible. The chemical is toxic to humans and other mammals; read and follow the label directions closely. For proper application techniques, see Minnesota Tree Line 4, *Root Graft Spread of Dutch Elm Disease and its Control.*

REMOVAL

Early detection and marking of diseased elms and dead elm wood do little good if they are not followed by prompt removal. All dead elm wood, including firewood piles, felled trees, standing dead trees, stumps, and brush, detected in the winter and early spring, must be removed from the control zone and taken to a designated disposal site by April 1, according to state law. This cleans up beetle and fungal harborage areas. Unfortunately, most native elm bark beetles in Minnesota escape these winter and early spring cleanup measures because, unlike the European beetles, they overwinter as adults at the bases of healthy elms. Therefore, additional strategies are needed to control these beetles (see page 12).

Removal of undebarked elm firewood from private yards is a critical and sensitive issue. It is critical because elm firewood storage represents one of the main hazards to a DED management program. Often the wood has been brought into the control zone from infected areas and contains the beetle carrier and the fungus. It is sensitive because the homeowner wants the right to use the wood as an energy source. In such cases, the community forester must tactfully explain the hazard and remove the wood or persuade the homeowner to debark it.

Ideally, diseased elms with greater than 5 percent wilt are removed as soon as they are detected and their stumps debarked or removed with a stump grinder. State law allows 20 days from time of marking to time of removal. Some community ordinances have limits as low as seven days.

In terms of the beetles' life cycles, June 1 and July 15 are crucial dates; they coincide with the main emergence periods of the adult elm bark beetle. All diseased elms detected in the spring (before June 1) should be removed by June 1. Diseased trees detected after June 1 should be removed no later than July 15. Removal of diseased elms by the above dates eliminates beetle breeding sites and interrupts the beetle life cycle before the adult beetles emerge. Emerging infected beetles feed on healthy elms, thereby transmitting Dutch elm disease. Removing elms promptly before the infection has spread to the main trunk also pays off in preventing root graft spread to nearby trees.

Many communities start their programs when they already have a considerable number of diseased trees and are forced to play "catch up." Other communities have severe limitations in personnel, money, and equipment, and may be unable to keep up with high losses. In these situations a priority system of tree removal should be established. The first trees to be removed, by July 15, are the high-risk trees (elms with more than 50 percent wilt). The second group of trees to remove, through the remainder of the summer, are the slow-wilting trees, and the third class of trees, those with other lethal diseases, major deficiencies, or severe damage, should be removed in the fall and winter. Once the community has caught up with the disease, it can move to a more comprehensive management program, adding the supplementary techniques described on the following pages.

If private contractors are involved in public tree removal, legally binding agreements should be drawn up. The community forester can help city administrators set up tree removal contracts; legal advice should also be obtained. Community foresters also coordinate the removal activities with the removal crew leaders to help maintain a high degree of efficiency and to make sure the job is completed on schedule.

DISPOSAL

Proper disposal is an indispensable part of DED management. The first step is for the community to select a suitable disposal site. The disposal site should be located one to three miles beyond the control zone and on the opposite side of the prevailing winds. It should be in an isolated area away from dwellings and wild elm populations. Easy road access is necessary and the roads must be able to tolerate large trucks and heavy loads. Disposal sites should not be located in flood plains where access might be denied part of the year.

Elm material taken to the disposal site must be burned, buried, chipped, or debarked within five days after arrival. Burning is

effective, but the resultant smoke pollutes the air; homeowner complaints to the Pollution Control Agency have caused many sites to be closed. Establishing a site further away from the control zone may alleviate the pollution problem but may result in higher transportation costs. Burying is also effective, but the large quan-

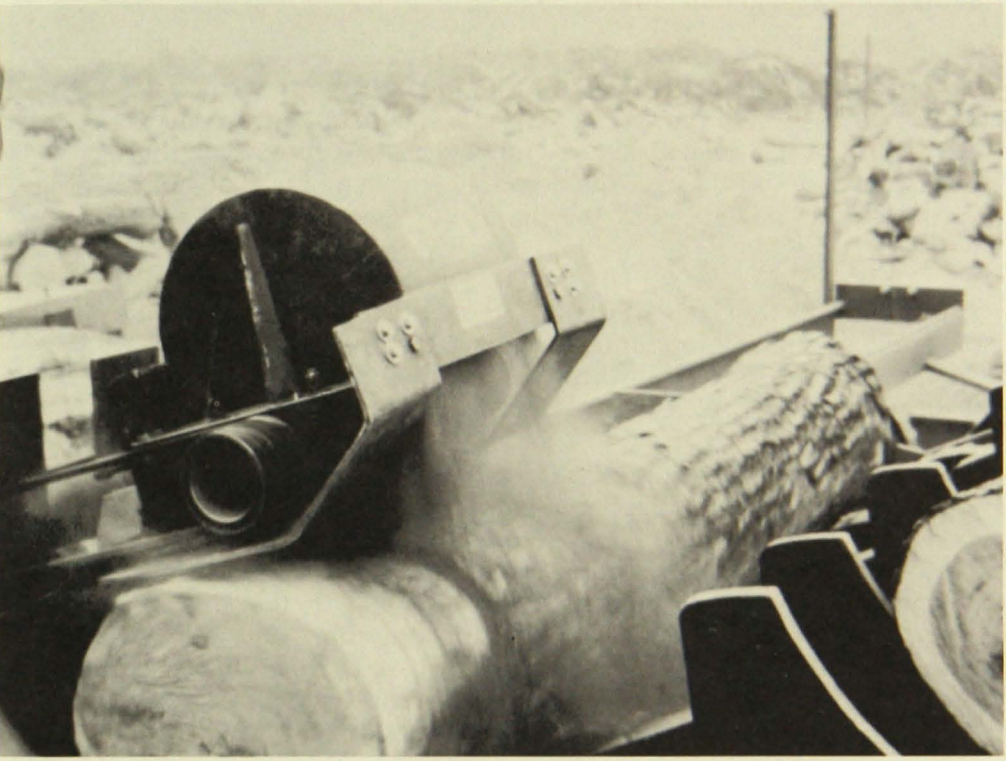

Figure 3. Debarkers eliminate beetle breeding sites but are often too expensive for a community to purchase and operate.

tity of logs resulting from an epidemic can require too much space. Both burning and burying exclude the possibility of utilization.

Chipping renders the wood safe from beetles or fungus and the chips can be utilized for mulch, animal bedding, nature trails, etc. Debarking, which is a mandatory procedure for elm wood stored between April 1 and September 15, allows for utilization as firewood or sawlogs. The main disadvantage of chippers and debarkers is that they are often too expensive for most communities (figure 3). The homeowner can debark elm wood by using an axe, hatchet, or wood chisel and hammer. It is best to debark the wood right after felling the tree, while there is still a thin film of moisture between the inner bark and the wood that allows the bark

to be stripped off rather easily. Once this moisture dries, the bark anchors tightly to the wood, making removal more difficult. Presently there is no acceptable compromise between DED management and utilization of wood with intact bark. However, current research offers hope for compatibility in the near future.

Additional Management Strategies

Although the primary emphasis in a Dutch elm disease management program is on detection, root graft disruption, removal, and disposal, there are other strategies which can be integrated into the program. These measures, however, are secondary to the basic four, and should be considered as supplements that help improve the management of the disease.

INSECTICIDES

In Minnesota two insecticides are registered for use against elm bark beetles, chlorpyrifos and methoxychlor. Insecticides, however, are limited in their effectiveness, and their use cannot be substituted for prompt removal and disposal of dead and dying elm wood.

Chlorpyrifos (sold commercially as Dursban) may be used as a supplement to sanitation to control overwintering native elm bark beetles. This beetle is the major, and in many instances the exclusive, carrier of Dutch elm disease in the northern two-thirds of Minnesota and an important carrier along with the smaller European elm bark beetle in the southern one-third. The native beetle overwinters mainly as an adult at the bases of healthy elms, thereby escaping late-season removal of dead or dying elm wood.

The native elm bark beetle's overwintering behavior provides a weak link in its life cycle that can readily be exploited by the application of an appropriate insecticide. Dursban 2E and 4E are registered in Minnesota for use on elm trunks to control overwintering native elm bark beetles. An organized spraying on a community-wide basis of all the elms in the control zone is recommended where the native beetle contributes significantly to DED spread. Before spraying is initiated, community foresters should employ sampling techniques to determine whether or not the native elm bark beetle is present and how high on the trunk it is necessary to spray. It is important to read the label and follow directions carefully. A state-certified operator must apply Dursban or be in charge of the spraying program. Minnesota Tree Line 27, *Native Elm Bark Beetle Control*, gives instructions on sampling and spraying.

Dursban should be applied to the lowest six feet of healthy elms with a 0.5 percent spray in mid-September, about two weeks

before the beetles start their search for overwintering sites in late September. The trunk should be wetted thoroughly but not to the point of runoff. Extra care should be taken to apply the aqueous spray to the basal (bottom) six inches, including the root flares, since the beetles tend to concentrate in these areas (figure 4). Although the insecticide is effective in killing beetles whether applied in September, October, or the following April, a September spray is recommended to prevent the beetles from transmitting Dutch elm disease as they make their overwintering tunnels. Young elms up to eight inches in diameter and thin-barked elms are especially susceptible to overwintering beetle transmission of Dutch elm disease.

This is not a technique to be used on just a single tree to reduce that tree's chance of becoming infected with Dutch elm disease. Therefore, it is not recommended for the individual homeowner. Insect control must be handled on a community-wide basis to effectively reduce the beetle population.

The smaller European elm bark beetle is not affected by this method since it overwinters as a larva in dead and dying elm wood rather than as an adult on healthy trees. Control of all elm bark beetles overwintering in the larval stage can best be achieved through sanitation—the prompt removal and proper disposal of diseased elms.

Figure 4. Insecticide is sprayed at the base of healthy elms to control overwintering native elm bark beetles.

The insecticide methoxychlor may be applied to the entire tree, but it is only partially effective in killing beetles or preventing feeding. Since methoxychlor acts slowly on the beetle as a stomach poison, it allows the beetle time to penetrate the bark and transmit Dutch elm disease before dying. Another disadvantage is that it is applied to tree crowns (at 2 to 12.5 percent concentrations, depending on the type of sprayer) and overspray and drift often occur. Other drawbacks are that it is toxic to fish and it is expensive. Although it adds a measure of protection, no amount of methoxychlor spraying could be as effective in eliminating bark beetles as proper wood disposal.

FUNGICIDES

Injection of elms with systemic fungicides to protect the tree from the DED fungus is an effective, but costly, preventive treatment recommended only for selected highly valued elms. Since this treatment is limited to a small percentage of the elm population, it has little effect on overall DED incidence in the control zone. Community foresters should incorporate fungicide injection into their management programs only after all major DED hazards have been eliminated from the community. Labor or resources must not be expended on injection if detection, root graft disruption, removal, and disposal have not been accomplished first.

The injection method is more likely to be used by the individual homeowner, who may seek the advice of the community forester on proper injection procedures. Community foresters, in turn, can use the services of the county agricultural extension agent to keep abreast of new developments and techniques. Extension Folder 504, *How to Inject Elms With Systemic Fungicides,* gives step-by-step instructions on injection techniques.

The most effective systemic fungicide currently available is thiabendazole, marketed as Arbotect 20-S. In Minnesota, a ruling by the Minnesota Department of Agriculture allows Arbotect 20-S to be used at three times the regular label rate for a period of two years starting May 28, 1980. At this higher dosage, the fungicide can be effective for at least two growing seasons if used properly. Complete and even distribution of the fungicide to all tree parts is necessary for adequate protection. To obtain even distribution, about two injection holes for every inch of the tree's diameter at breast height must be drilled into the below-grade root flares, spaced 4 to 8 inches apart (figure 5). Repeated injections can cause enough injury to kill the tree.

The worst time to drill into a tree is in the spring at budding time because most of the tree's energy is needed for the budding

Figure 5. To be effective, fungicides must be injected in the root flares.

process and little energy can be spared for walling off an injury. The best time for drilling is July, when the tree is at peak strength. Drill bits (3/16 to 5/16 inch in diameter) must be kept extremely sharp to avoid unnecessary injury and to insure uptake of the chemical solution. Drill holes should be no deeper than 1½ to 2 inches. Depth into the white wood beneath the bark should be no greater than 1 inch. A steel washer placed over the drill bit at the proper depth will insure uniformity.

If injection is done improperly, toxicity may develop, causing the leaves to discolor and, in some instances, to drop from the tree about one week after injection. Toxicity at the injection point may also occur. If proper pressure (0-10 psi) and chemical concentration are used, the danger of injection-point toxicity is greatly reduced.

The homeowner may want to inject a tree after it has become infected (therapeutic injection). Therapeutic treatment is not recommended for those trees infected via root grafting or where the infection is far advanced, because there is very little chance of success. Elms infected by elm bark beetles feeding high in the crown and detected when crown symptoms appear in 5 to 10 percent of the tree may be suitable for injection. With these trees a 50 percent or better survival rate may be expected. Therapeutic injection should be combined with pruning (see page 18).

The difficulty of fungicide injection, the expense, and the limited chances for success should be considered carefully before deciding whether to go ahead with either preventive or therapeutic injection. It is also important to know the proper application techniques. Community foresters should encourage homeowners to read the available literature to gain an understanding of Dutch elm disease and of injection procedures and to carefully follow the manufacturer's instructions on the label. Injection stands a better chance of success in communities where diseased elms are removed and disposed of promptly and beetle brood wood (such as elm firewood with intact bark) is destroyed or debarked. If this is not done in areas where the disease incidence is high, valuable elms should be injected only if they can be protected from root graft transmission of the DED fungus.

SELECTIVE AND CLEAR CUTTING

Selective cutting is defined as the removal and disposal of elms severely stressed from any cause other than Dutch elm disease. Selective cutting is incorporated into DED management programs because weakened trees are often attacked by elm bark beetles. The beetles use these trees as breeding sites, and such trees may become infected by the fungus-carrying beetles. These losses would seem insignificant in a community where Dutch elm disease was epidemic. However, once a community has caught up to the disease and has implemented proper detection, root graft disruption, removal, and disposal, the incidence of Dutch elm disease in elms first weakened by other factors is greater than in healthy elms. In one study the infection rate in trees weakened by leaf scorch was 14.8 percent compared with 1.2 percent for elms not stressed by leaf scorch.

Structurally weakened elms severely damaged by wind storms, ice storms, lightning, or other adverse weather conditions, or by mechanical causes (e.g., street widening operations), salt injury, or other diseases are candidates for selective cutting. The community forester has to make the decision on whether a tree is damaged to the extent that removal is warranted. In some cases the need for removal will be obvious. In borderline cases first considerations should be given to measures aimed at saving the tree, such as pruning, watering, and fertilizing. Besides the main benefit of reducing potential beetle breeding and fungal harborage sites, selective cutting has the additional advantage of creating space between elms. That space may be enough to prevent the joining of different root systems, thereby preventing DED spread via root grafting.

Clear cutting is the elimination of pockets of wild elms that, because of location, are difficult to reach for DED monitoring and

control. It is undertaken on a limited basis by communities. Community foresters may notice groups of wild elms serving as a continuing source of Dutch elm disease within the designated control zone and may recommend that they be clear cut. These small wild elm areas may include river islands, ravines, river bottoms, or any other location where access is difficult (figure 6).

As disease management within a control zone becomes successful, the impact of wild areas becomes more important. If surrounding wild areas have an abundance of elms and the control zone still has DED hazards (e.g., plenty of brood wood and standing diseased elms), the primary emphasis should be on cleaning up the control zone. The fungus and beetles will tend to stay in the wild areas as long as there is a sufficient mixture of living and dying elms. Movement of the disease into the control zone will be negligible, and the threat from the wild area relatively minor compared with DED hazards within the zone.

If the wild areas have abundant elms and the management program in the control zone is excellent (i.e., few existing beetles and diseased trees), the primary emphasis can shift to clear cutting the wild areas. In these cases, although movement of the disease into the control zone is still slow, the wild areas are more of a threat as sources of new infection and should be clear cut.

Figure 6. Areas containing wild elms may require clear cutting if they pose a threat to the control zone.

If the disease in the wild area is rampant, with an increase in beetle populations combined with rapidly diminishing elm trees, then the danger to the control zone increases because the beetles will start flying into the control zone in search of elms. In this situation, high priority should be given to both the wild areas and the control zone. Through periodic observation of wild areas, this situation can be anticipated and planned for. The critical period (when the diminished wild elm population can no longer support the increased beetle population, causing the beetles to seek elms in the control zone) usually occurs over a short period of time (about one or two growing seasons). A single clear cutting will eliminate the DED hazard to the control zone; therefore, proper wild area sanitation is not an ongoing activity.

PRUNING

Pruning elms can either help or hinder a DED management program, depending on the kind of pruning and when it is done. There are three basic kinds of pruning: aesthetic, sanitation, and therapeutic.

Aesthetic pruning is part of the routine maintenance regularly scheduled for all trees in a community. Its purpose is to give trees desired structure and appearance. In a DED management program, aesthetic pruning of healthy elm limbs should not be done during spring and summer, because the pruning wounds attract elm bark beetles and DED infection may result. Community foresters should schedule aesthetic pruning only during the beetles' inactive period from mid-October to the end of March.

Sanitation pruning is the removal of elm branches that are dead or dying from any cause. This type of pruning reduces the number of breeding sites for elm bark beetles and is therefore an integral part of the community's DED management program. Although sanitation pruning is conducted all year, it is safer if done in the fall and winter, when the beetles are inactive. However, summer storms or other events causing tree damage may make spring and summer pruning unavoidable. In such cases, the risk of attracting beetles to the pruning wounds is minor compared with the benefits of removing potential beetle breeding areas.

Therapeutic pruning is the removal of branches already infected with Dutch elm disease in order to save the tree. It is conducted during the spring and summer when disease symptoms appear. Therapeutic pruning works only if the elm has been infected via beetles and not through root grafts. It is most effective on large trees with small infections. Homeowners are more likely to use this control technique because they are able to watch their elms daily and detect Dutch elm disease in its early stages.

Therapeutic pruning is most successful in communities with good DED management, where populations of elm bark beetles are small and beetle-carried infections are few. The degree of success also depends in part on the pruning technique used. The distance from the pruning cut to the nearest brown or blue-gray discoloration of Dutch elm disease in the pruned branch should be 10 feet or more. If there are at least 10 feet of unstained wood on the pruned branch, up to 85 percent of the pruned elms will survive. If the stain-free distance is less than 5 feet, less than 15 percent of the elms will survive. Of course, if the infection reaches the main trunk, the tree is lost.

Tree wound dressings applied to pruning wounds made during the spring and summer may help render the elms less attractive to the beetles. Wound dressings are not needed when elms are pruned between mid-October to the end of March.

BIOLOGICAL AND NATURAL FACTORS

Elm bark beetles have many enemies. They are eaten by birds, other insects, mites, and nematodes, but where Dutch elm disease is present these agents do not kill enough beetles to influence the infection rate. Woodpeckers feed on overwintering beetle larvae, and the tree inspector can use the highly visible woodpecker holes as an indicator of the presence of beetle brood wood and of the beetles.

Several species of wasps parasitize the beetle larvae. One species was deliberately introduced from Europe into the midwestern United States to help control the European elm bark beetle. However, it is not effective against the native elm bark beetle and provides only a small increment of protection against the European beetle.

The long, cold Minnesota winters take their toll of overwintering European elm bark beetle larvae. In the Twin Cities during a normal winter, only 2 or 3 percent of these larvae survive in elm wood that is above the snow line, whereas 23 percent survive below the snow line. The colder weather in the north may be the reason why the European beetle is mainly confined to the southern one-third of the state. The native beetle is better adapted to Minnesota winters and is found throughout the state. If the winter is particularly severe, the community forester can anticipate a reduction of the DED rate.

The DED fungus grows best at room temperatures and its growth is retarded by cold. Therefore, a late spring may aid a DED management program by slowing down the rate of fungal growth.

REPLANTING

Given enough time, the American elm, through natural selection of resistant trees, may persist. But the immediate future will see continued losses of urban elms. A well-planned tree planting program, providing for a balance of several species, will help avoid possible epidemics in the future.

Planting elms in Minnesota to replace those lost to Dutch elm disease is not recommended at this time. Although Siberian elms are quite resistant to Dutch elm disease, and other resistant species and hybrids (e.g., the Sapporo autumn gold elm) have been developed as replacement trees, they may serve as reservoir hosts for the DED fungus and therefore present a further danger to the native elm species (American, red, and rock). Some of the resistant species are fast growing but structurally weak, so they tend to lose their branches. They also don't have the desirable shape or height of the American elm. Some suffer winter damage and are short-lived.

American elms were overplanted (up to 95 percent of boulevard trees) 50 to 70 years ago, partly because of the beauty of elm-lined streets with their cathedral effect, but mostly because they grew fast and to a good height and were very tolerant of urban stresses. Replacement tree species may require more maintenance than elms, but they will lead to a more stable urban forest.

ADDITIONAL PUBLICATIONS ON DUTCH ELM DISEASE MANAGEMENT

These publications are available from the University of Minnesota Agricultural Extension Service or from county extension agents.

Tree Management in Minnesota Communities. Extension Folder 511.

Dutch Elm Disease—Community Experiences. Minnesota Tree Line 5.

The Dutch Elm Disease. Extension Bulletin 415.

Dutch Elm Disease Detection. Minnesota Tree Line 6.

Identifying Elm Firewood. Minnesota Tree Line 25.

Root Graft Spread of Dutch Elm Disease and its Control. Minnesota Tree Line 4.

How to Inject Elms With Systemic Fungicides. Extension Folder 504.

Utilizing Diseased Elm in Minnesota. Extension Bulletin 412.

Native Elm Bark Beetle Control. Minnesota Tree Line 27.

Street Trees for Minnesota. Horticulture Fact Sheet 22.

Shade Tree Evaluation. Extension Folder 445.